

REMARKS

Examiner Kielin is thanked for his ongoing and careful examination of the subject Patent Application. Claims 5, 7, 8, and 9 were canceled in response to Examiner's rejections. Claims 6, 10, and 11 were amended to now depend on claim1.

Briefly, Applicant wishes to reiterate the major features of his invention. One major problem associated with the formation of damascenes is chemical mechanical planarization (CMP) because the complete removal by CMP of metal film on silicon oxide ( $\text{SiO}_2$ ) is extremely difficult or results in dishing of the damascene conductor. This invention combines these new features:

- a) depositing a barrier metal and a seed layer in a damascene trench,
- b) electroplating a copper layer on top of the seed layer,
- c) forming of a (reverse tone) photoresist mask,
- d) etching away the copper and seed layer by means of reverse current electroplating (electropolishing), and
- e) planarizing the now exposed copper and barrier metal layer.

The proposed invention avoids the aforementioned dishing through a reduced need for polishing. The invention furthermore features the applying of a "relaxed" tone photoresist mask where spaces between trenches are covered, if the trenches are separated by less than a critical distance.

2. Reconsideration of the rejection of Claims 5-12 under 35 U.S.C. 103(a) as being unpatentable over Lin (US 6,093,656) is requested, in light of the following arguments.

Claim 5 was canceled and therefore the rejection is moot.

Claim 10 was amended to depend on claim 1. Because claim 1 is now believed patentable, as argued below, dependent claim 10, therefore, is also believed patentable.

Claim 6 was amended to depend on claim 1. Because claim 1 is now believed patentable, as argued below, dependent claim 6, therefore, is also believed patentable.

Claims 7, 8, and 9 were canceled and therefore the rejection is moot.

With regards to claims 11 and 12, Applicant respectfully disagrees with the Examiner. Lin's discussion of the reverse tone photoresist mask, while thorough with respect to the use of positive and negative photoresist, does not treat the subject of size except to say in col. 3, line 65-67 "*Generally, it has been determined that a positive photoresist can transfer smaller patterns so it is better for smaller line widths than a negative photoresist.*" This is indeed a very general statement merely pointing out in which direction a process moves. By contrast, Applicant's claims 11 and 12 are very specific, clearly pointing out that the reverse tone photoresist mask covers spaces

between damascene trenches having a separation of less than a critical distance, where "said critical distance ranges from 0.05  $\mu\text{m}$  to 0.2  $\mu\text{m}$ ." Applicant disputes that these critical dimensions are *prima facie* obvious, because there is no prior art range given by Lin.

3. Reconsideration of the rejection of Claims 1-2, and 4 under 35 U.S.C. 103(a) as being unpatentable over Lin (US 6,093,656) and in view of **Datta** et al. (US 5,567,300) is requested, in light of the following arguments.

Taken individually, Applicant does not debate Examiner's three points:

point (1), that it is known that dual damascene is also subject to dishing during metal planarization (**Fiordalice** et al., US 5,578,523) or that damascene, dielectric trenches have "at least two levels of elevation" (**Lin**), nor

point (2), that seed layers and electroplating are notoriously well known in the art, including Lin's teaching that the blanket deposition of copper "could be done in a number of different ways...", nor

point (3), that **Datta** and references teach the benefits of reverse current electroplating for the purpose of removing unwanted metal,

because strictly by themselves all three points are valid. However, Applicant has combined these three, unrelated inventions into a new and unique invention—and this is

TSMC97-542/TSMC98-021

in the very nature of an invention— which allows reverse electroplating (electropolishing) to remove Cu from large open areas of the semiconductor surface providing unique benefits not available until now:

- The invention allows precise control of the amount of Cu to be removed from the field areas.
- The invention allows the use of “end point detectors” for precise control which is imperative for the sub half-micron technology.
- The invention allows applying a “relaxed” tone photoresist mask where spaces between trenches are covered, if the trenches are separated by less than a critical distance.

The electropolishing method disclosed by Applicant is thus a much more advanced method, as opposed to Lin's wet etch or Datta's electrochemical metal removal, and, therefore, eminently more suitable for future technology development.

Applicant has disclosed a combination of features which neither Lin nor Datta nor Fiordalice individually anticipated, the combination of which makes Applicant's invention different and not obvious, there having been no prior art teachings relating to Applicant's invention.

In summary, nowhere does Lin suggest that anything else other than a wet etch (col. 4, line 15-16) is possible and Datta does not anticipate the use of a photoresist

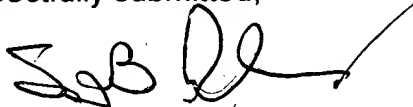
TSMC97-542/TSMC98-021

mask. Applicant must conclude that there is proposed by Examiner a combination of references that has no basis in Lin, Datta or Fiordalice and can only be suggested after reading Applicant's patent application and claims.

All claims are now believed to be allowable.

It is requested that should Examiner Kielin not find that the Claims are now Allowable that he please call the undersigned attorney at (845) 452-5863, to overcome any problems preventing allowance.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'S.B. Ackerman', with a long horizontal stroke extending to the right.

Stephen B. Ackerman, Reg # 37,761